Interrelations Among Expectancies, Task Values, and Perceived Costs in Undergraduate Biology Achievement

Tony Perez[a], Ting Dai[b], Avi Kaplan[c], Jennifer G. Cromley[d], Wanda D. Brooks[a],
Arianna C. White[a], Kyle R. Mara[e], & Michael J. Balsai[c]

[a]Old Dominion University, 5115 Hampton Blvd., Norfolk, VA 23529, acperez@odu.edu,
wbroo003@odu.edu, awhit141@odu.edu

[b]University of Illinois at Chicago, 1040 W Harrison St., Chicago, IL 60607, tdai@uic.edu

[c]Temple University, 1801 N Broad St., Philadelphia, PA 19122, akaplan@temple.edu,
mjbalsai@temple.du

[d]University of Illinois at Urbana-Champaign, 1310 South Sixth St., Champaign, IL 61820,
jcromley@illinois.edu

[e]University of Southern Indiana, 8600 University Blvd., Evansville, IN 47712,
kyle.mara@usi.edu

Manuscript accepted for publication on April 2, 2019 in Learning and Individual Differences.

This research was supported by a grant from the Institute of Education Sciences under award number R305A140602.

Declarations of interest: none

Correspondence concerning this article should be addressed to Tony Perez, Department of Educational Foundations and Leadership, Old Dominion University, Education Building 2312, Norfolk, VA 23529.

Email: acperez@odu.edu

Abstract

Expectancy-value theory highlights the roles of students' expectancies, task values, and perceived costs in their motivation and achievement. While ample research has highlighted the positive associations of expectancy beliefs and task values with academic achievement, research on students' perceived costs is in its infancy. We investigated the temporal interrelations among expectancies, task values and different types of perceived cost, the role of these constructs in biology achievement, and the role of perceived costs as a moderator in the relations of expectancy beliefs to biology achievement. A cross-lagged path analysis of semester-long data from 234 undergraduate biology students pointed to variable relations among expectancies, task values, perceived costs, and biology achievement. For example, while early expectancy beliefs related to later attainment and interest value, early task values and perceived costs did not relate to later expectancy beliefs. Furthermore, early attainment value related to later effort and opportunity cost. Expectancy beliefs and effort and opportunity cost in biology were associated with final biology grade. Finally, effort cost moderated the relationships between expectancy beliefs and students' final grades. These findings provide evidence for the dynamic relations among perceived costs, task values, and expectancy beliefs over a semester and point to the interplay between expectancies and perceived costs in their relation to academic achievement in science.

Keywords: motivation; perceived costs; expectancy-value; science achievement

Interrelations Among Expectancies, Task Values, and Perceived Costs in Undergraduate Biology Achievement

1. Introduction

Students' motivation for choosing and investing in an academic task is undergirded not only by positive draws such as interest and desire to achieve (i.e., task values) but also by concerns about the drawbacks of engaging in the task (Eccles et al., 1983). Yet, until recently, motivational research has focused primarily on the positive incentives for engagement with much less attention given to those perceived downsides and obstacles. The perceived drawbacks, or perceived costs, of engaging in a task may play a particularly crucial motivational role in the context of challenging introductory undergraduate science, technology, engineering and math (STEM) courses that often serve as a gateway into the STEM career pipeline. Indeed, previous research has found that many students describe the time and effort requirements for STEM courses as too difficult and as a main reason for leaving the major (Seymour & Hewitt, 1997). Yet, there have been few studies examining the role of perceived costs in achievement and persistence in STEM (Barron & Hulleman, 2015; Wigfield & Cambria, 2010). Furthermore, there have been few studies examining the reciprocal effects of such incentives and drawbacks on each other over time. Understanding how these perceived drawbacks are formed and their effects on STEM achievement is important for understanding and intervening in attrition from STEM disciplines.

The theoretical framework guiding this study is Expectancy-Value theory (EVT; Eccles et al., 1983). EVT is a prominent motivation theory that explains students' choice of, achievement in, and persistence in academic tasks. EVT research in the past three decades highlights the positive relationships of students' expectancy beliefs and task values to their academic achievement and persistence (see Wigfield & Cambria, 2010; Wigfield & Eccles, 2000; Wigfield, Tonks, & Klauda, 2009 for reviews). However, a gap remains in this body of research regarding the relations of students' cost perceptions to such outcomes (Barron & Hulleman, 2015; Wigfield & Cambria, 2010). Emergent research on perceived costs supports

hypotheses that cost perceptions are negatively related to outcomes such as achievement and persistence intentions (e.g., Battle & Wigfield, 2003; Trautwein et al., 2012) and are positively related to undesirable outcomes such as students' emotional risk factors and their intentions to leave an undergraduate major (e.g., Author et al., 2014; Dever, 2016). However, there is still very little that is understood with regard to the role played by different types of perceived cost in students' academic outcomes, especially alongside the role of the different types of value (Trautwein et al., 2013). Furthermore, there has been little research on how success expectancies, values, and costs relate to each other over time. Finally, there are open questions regarding whether the relations between expectancy beliefs and academic achievement outcomes are similar among students with different levels of perceived costs (Barron & Hulleman, 2015; Trautwein et al., 2013). While there has been some research on effects of interactions between task values (including perceived costs) and expectancy beliefs on academic outcomes (e.g., Guo, Parker, Marsh, & Morin, 2015; Guo et al., 2016; Nagengast et al., 2011), additional research is needed to understand interactions between expectancy beliefs and costs, particularly with regard to the interactive effects of expectancy beliefs and the cost subcomponents.

In the current study, we investigated the temporal relations of perceived costs, task values, and expectancy beliefs across a semester in a sample of undergraduate students in a gateway biology course. Specifically, we pursued three aims. First, we examined the reciprocal relations among expectancy beliefs, task values, and perceived costs over two time points within the semester. Second, we examined the unique associations of perceived costs with biology course achievement, after accounting for task values and expectancy beliefs. Third, we examined whether perceived costs moderated the relations between expectancy beliefs and biology course achievement. The findings of this study can contribute both to theory and research in expectancy-value theory and to research on motivational factors underlying achievement in gateway STEM courses.

1.1 The Expectancy-Value Model of Achievement Motivation

According to Eccles's and colleagues' Expectancy-Value model of achievement motivation (Eccles et al., 1983), students' choices to engage and persist in a task–and their success on the task–are contingent on their: 1) ability beliefs/expectancies to succeed on the task, 2) valuing of the task, and 3) cost perceptions for engaging in the task (Barron & Hulleman, 2015; Eccles, 2009; Eccles et al., 1983). Over 30 years ago, Eccles and her colleagues (Eccles et al., 1983) proposed an expectancy-value model that included three types of task-value—attainment value, utility value, and intrinsic/interest value—and specified perceived costs as a contributing factor to the overall value of the task. In subsequent writings, perceived costs were presented as an additional component of task values (Wigfield & Cambria, 2010). This model has generated a sizable body of research on the development of expectancy beliefs and task values and their relations with academic outcomes. However, recently, scholars have argued that the perceived cost component is distinct from other task values and that it should be considered as its own separate category (Barron & Hulleman, 2015).

1.1.1 Ability beliefs and expectancies for success in the task

Ability beliefs and expectancies for success in the task refer to self-beliefs about one's ability in a domain and whether one can be successful on a task. These perceptions are conceptually similar to other competence beliefs including academic self-concept and self-efficacy (Trautwein et al., 2013; Wigfield & Eccles, 2000). Empirically, Eccles and Wigfield (1995) found that ability beliefs and expectancies for success are indistinguishable. Therefore, these constructs are often combined in expectancy-value research. In this study, we follow the precedent of combining ability beliefs and expectancies for success and we refer to this combined construct as expectancy beliefs from this point forward.

1.1.2 Task values

Task values are the features of the task that attract an individual to engage in and persist in the task (Eccles et al., 1983). Task values include 1) attainment value, which refers to aspects of the task that the student perceives as important to his or her identity, 2) utility value, which refers to perceptions about the usefulness of engaging and succeeding in the task for achieving

future goals, and 3) interest value, which refers to beliefs about the enjoyment or interest the student would derive from engaging in the task.

1.1.3 Perceived costs

Perceived costs concern perceived drawbacks associated with engaging in the task. Theoretical conceptualizations of perceived costs (Eccles et al., 1983), as well as recent empirical research (Battle & Wigfield, 2003; Flake, Barron, Hulleman, McCoach, & Welsh, 2015; Perez, Cromley, & Kaplan, 2014;), have identified at least three different perceived cost components, including 1) effort cost, which refers to the belief that the time and effort required to succeed in the task are high and may not be worthwhile, 2) opportunity cost, which refers to the perception that other valued activities must be sacrificed in order to complete the task, and 3) psychological cost, which refers to the fear of failure and psychological threat associated with engagement in the task (Eccles et al., 1983). Other perceived cost dimensions have also been identified, including emotional costs, ego costs, and outside effort costs (Flake et al., 2015; Gaspard et al., 2015; Jiang, Rosenzweig, and Gaspard, 2018). There are similarities across some of these cost dimensions in their conceptualization and measurement. For example, there is considerable overlap between psychological cost as it is operationalized in this study and ego cost as it is operationalized in Jiang et al. (2018). Indeed, one could argue that these constructs are one and the same; however, addressing such theoretical considerations is beyond the scope of this study. In this study, we use the term psychological cost, which is in line with terminology used in prior research (Perez et al., 2014) and in prior theorizing about cost perceptions (Eccles et al., 1983). Further, we focus on effort, opportunity, and psychological costs (Eccles et al., 1983) in this study as these constructs may be particularly relevant in STEM disciplines (Perez et al., 2014; 2019) given the challenges associated with pusrsuing STEM majors (Hurtado, Newman, Tran, & Chang, 2010).

According to the expectancy-value model, students will be ideally motivated when expectancy beliefs and task values are high, and perceived costs for the task are low. Importantly, while expectancy-value theory does not make clear predictions about whether the

different types of perceived cost might have different relations with outcomes, such differences were found in prior research (Perez et al., 2014). Perez and colleagues previously examined the relations between effort, opportunity, and psychological costs and STEM outcomes and found that effort cost had the strongest relation to intentions to leave the STEM major. In comparison, opportunity cost had a small relation and psychological cost was not related to the outcomes. Thus, while EVT suggests that any type of cost will reduce the student's motivation to choose and invest in the task, it may be that different types of perceived costs play different roles for students with different characteristics, in different situations, and perhaps for different types of tasks. Clearly, more research is needed to determine if different perceived costs have different relations with outcomes in STEM. Therefore, in this study, we examine the unique relations of each of these different perceived costs to achievement alongside expectancies and different types of task values.

1.2 Interrelations of Expectancy Beliefs, Values, Costs, and Academic Outcomes

Research on the relations of different competence beliefs (expectancy beliefs, self-efficacy, and self-concept) and task values with academic outcomes is abundant (see Trautwein et al., 2013 and Wigfield & Cambria, 2010 for reviews). Multiple studies with different student populations and in different contexts have found that both competence beliefs and task values are positively related to academic achievement and persistence, including in STEM domains (e.g., Acee & Weinstein, 2010; Bong, 2001; Chen & Liu, 2009; Chow, Eccles, & Salmela-Aro, 2012; Durik, Vida, & Eccles, 2006; Eccles, 1987; Hulleman, Godes, Hendricks, & Harackiewicz, 2010; Luttrell et al., 2010; Meece, Wigfield, & Eccles, 1990; Neuville, Frenay, & Bourgeois, 2007; Perez et al., 2014; 2019; Simpkins, Davis-Kean, & Eccles, 2006; Sullins, Hernandez, Fuller, & Tashiro, 1995; Watt, 2006; Watt et al., 2012; also see Cromley, Perez, & Kaplan, 2016 and National Academies of Sciences, 2017). Furthermore, studies generally find that competence beliefs, such as expectancy beliefs, relate more strongly to academic performance while task values typically relate more strongly to achievement-related choices, such as choosing a course of study or persisting in a major (see Barron & Hulleman, 2015; Trautwein et al., 2013; Wigfield

et al., 2009). Whereas Eccles et al. (1983) posited that–similarly to task values–perceived costs would be especially relevant for decision-making and choice, the emerging research suggests that perceived costs may relate to a variety of academic outcomes (Battle & Wigfield, 2003; Conley, 2012; Dever, 2016; Gaspard et al., 2015; Luttrell et al., 2010; Perez et al., 2014; Trautwein et al., 2012). For example, perceived costs were found to be negatively related to high school math achievement (Trautwein et al., 2012), middle school students' adaptive academic emotions (Conley, 2012), and female undergraduates' intentions to enroll in graduate school (Battle & Wigfield, 2003), and positively related to undergraduates' intentions to leave STEM majors (Perez et al., 2014) and to emotional problems in high school (Dever, 2016). However, the body of research on perceived costs is still in its infancy and many questions remain. One central domain requiring further research concerns the temporal relations of perceived costs with expectancy beliefs, task values, and academic achievement. Another question concerns the nature of the relationship between perceived costs and achievement when combined with expectancy beliefs and task values.

In the current study, we pursued three specific questions that have been identified as foundational within this emerging domain of inquiry (Barron & Hulleman, 2015; Trautwein et al., 2013): (1) what are the interrelations among expectancy beliefs, task values and perceived costs over time, (2) what are the relations of perceived costs with academic achievement when controlling for expectancy beliefs and task values, and (3) do the relations of expectancy beliefs with academic achievement differ across different levels of perceived costs, in the same way that relations of expectancy beliefs with achievement differ across different levels of task values? We review literature that is relevant to each of these questions below.

1.2.1 The interrelations among expectancy beliefs, task values, and perceived costs

There has been little prior research on the interrelations of expectancy beliefs, task values and perceived costs over time, particularly within a semester. In one study, which examined the relations of growth in expectancies and utility value within a single semester gatekeeper psychology course, Kosovich, Flake, and Hulleman (2017) found that the starting value of

expectancy was correlated with the starting value of utility value ($r = .52$, $p < .05$) and that changes in expectancy and utility value were highly correlated ($r = .83$, $p < .05$). In other words, students who started the semester with higher expectancy beliefs also started with higher utility value perceptions. Furthermore, students who increased in their expectancy beliefs over the semester also increased in their utility value over the semester. Additionally, there is some long-term longitudinal research that is suggestive of the relations between competence beliefs and task values. Jacobs, Lanza, Osgood, Eccles, and Wigfield (2002), in a longitudinal study with children spanning from 1st through 12th grade, found that competence beliefs were predictive of task value growth trajectories. While Jacobs and her colleagues did not test whether task values were predictive of competence beliefs, yet the authors acknowledged such a possibility. In a more recent study, Nuutila and colleagues (Nuutila, Tuominen, Vainikainen, & Niemivirta, 2018) found that task-specific success expectancies related to domain-specific intrinsic value in 6th grade. Task interest also predicted domain-specific self-concept. However, success expectancies and task interest in 4th grade were not related to each other in 6th grade. Using similar constructs to this study, Chen et al., (2016) found that self-efficacy predicted the intercept and slope for situational interest with a sample of late elementary school students. Fryer and Ainley (2017) found, with a sample of Japanese first-year university students, that interest, but not utility value, predicted later self-concept (similar to the expectancy variable in this study) and self-efficacy. Self-efficacy, but not self-concept, also predicted interest over time. In another study with a similar sample, Fryer, Ainley, and Thompson (2016) found that self-efficacy and self-concept predicted task interest three weeks later.

While these studies provide some insight into the potential interrelations among expectancy-value constructs, they did not test these relations over time within the context of a semester course and none included multiple forms of perceived costs or task value despite the theoretical and empirical importance of examining the subcomponents of these constructs (Trautwein et al., 2013). Thus, an important question is how starting levels of expectancy beliefs, different task values, and different perceived costs in a course relate to each other over time

within the semester and to achievement at the end of the course. Based on this limited prior literature, we can anticipate that expectancies may shape task values and vice versa. However, how expectancies and task values will relate to costs is unclear based on the lack of prior research on perceived costs.

1.2.2 The relations between perceived costs and academic achievement

Only a few prior studies exist that can provide insights into the relations between perceived costs and academic achievement while accounting for expectancy beliefs and task values. Perceived costs were associated with achievement in some studies (e.g., Guo et al., 2016; Trautwein et al., 2012) but not in others (e.g., Perez et al., 2014). Moreover, most prior studies that reported on these relations while controlling for task values and competence beliefs either controlled only for competence beliefs (e.g., Trautwein et al., 2012) or included perceived cost measures that targeted choice of major (leaving a STEM major) rather than perceived cost for a specific course (Perez et al., 2014). As an exception, Jiang et al. (2018; study 2) examined the role of a general cost variable in four outcomes including math achievement (mid-term exam scores) with 8th grade Korean students. They found that the composite cost variable predicted math achievement, procrastination, and avoidance intentions after controlling for self-efficacy and a composite task-value variable. Similarly, Guo et al. (2016) found that a second-order cost variable was related to math achievement, controlling for task values, in a large sample of German high-school students. These studies lend support to the significant relations between perceived costs and academic achievement, even while controlling for competence beliefs; however, questions remain about the unique effect of different cost subcomponents.

Gaspard et al. (2018) examined the associations of achievement with a variety of expectancy-value motivational constructs with German middle school and high school students and found that the associations between prior achievement and the various expectancy-value beliefs varied by subject domain. For example, they found that prior achievement in a domain was, on average, positively predictive of self-concept beliefs and various task values (including low perceived costs) when such beliefs were measured in the same domain. However, the

relations of prior achievement in non-matching domains (e.g., the relations between English achievement and intrinsic value for math) were negative, on average. In other words, higher achievement in math led to higher math self-concept but lower English self-concept. With relation to perceived costs, higher achievement in math led to lower perceived costs in math but higher perceived costs in English. Thus, this study demonstrated interesting within and cross-domain effects of prior achievement on expectancy-value motivational beliefs. However, these models did not test how expectancy-value motivational beliefs related to later achievement in a single model. In the current study, we examined the unique relations between the perceived cost subcomponents and academic achievement in an undergraduate biology course, controlling for the effects of expectancies and task values on achievement in the course.

1.2.3 The moderating role of perceived costs

Finally, in the current study, we also focus on the potential moderating effect of perceived costs on the relations between expectancy beliefs and academic achievement. The interaction of expectancy beliefs and task values on academic outcomes was a foundational assumption in early expectancy-value theory. Despite this, and the importance of this process to understanding the interplay of expectancy beliefs, task values, and perceived costs, this moderation effect has received less attention in contemporary research (see Trautwein et al, 2013 for a review). While expecting success in a course or feeling competent in a particular domain is associated with academic success in the course, perceiving costs in the course may be disruptive to this relationship. As an avoidance motivation, perceiving costs may lead to disengagement with the course leading to lower success in the course. For example, if a student believes she can be successful with effort in a science course but also feels like the effort is not worthwhile, she may engage in maladaptive behaviors (Jiang et al., 2018). Thus, it is important to examine the combined effects of expectancy beliefs and perceived costs to determine if such beliefs may disrupt the benefits of expectancy beliefs for academic achievement.

A few recent studies have tested the interactive effects between competence beliefs (e.g. self-concept) and task values (e.g., Guo et al., 2015; Nagengast et al., 2011; Trautwein et al.,

2012) and found that task values moderate the relations between competence beliefs and academic outcomes. For example, Nagengast and colleagues (2011) found a small, yet significant self-concept × enjoyment (i.e., interest value) interaction effect on both science extracurricular activities and science career aspirations with a large sample of students from the Programme for International Student Assessment (PISA) data. Results indicated that the strength of the positive relation between self-concept and participation in science extracurricular activities decreased with lower rates of science enjoyment, with no relationship at all at low levels of enjoyment. Similarly, the strength of the positive relationship between self-concept and science career aspirations increased as science enjoyment increased.

A few studies have also investigated interaction effects of competence beliefs and perceived costs on academic achievement (Guo et al., 2016; Trautwein et al., 2012). Trautwein et al. (2012) found that adding an expectancy × low cost interaction (higher cost scores indicated *lower* cost perceptions) to their analysis explained significant additional variance in both math and English achievement. They found the same positive interaction effect of expectancy and perceived low cost as they did for the interaction of expectancy and task values on achievement. At higher levels of expectancy beliefs, the relations between task value and achievement was positive. Achievement was highest when both expectancy and task values were very high. Similarly, with perceived cost, at high levels of expectancy beliefs, higher perceived costs were related to lower achievement and achievement was highest when expectancy was very high and perceived cost was very low. Interestingly, when expectancy was very low, higher perceived costs related to higher achievement relative to very low expectancy and very low perceived cost. While Trautwein and his colleagues conceptualized expectancy as a moderator of the relations between perceived costs and achievement rather than perceived cost as a moderator of the relations between expectancy and achievement (as we do in this study), the results were consistent with theory in that they suggested that achievement was highest when expectancy was high and costs were low.

A second study examined low cost as a moderator of the relation between self-concept and math achievement (Guo et al., 2016). Similar to findings in Trautwein et al. (2012), Guo and colleagues found that the relation between self-concept and achievement was stronger at lower levels of cost. In other words, as Trautwein and his colleagues found, the results suggested that achievement was highest when self-concept was high and perceived costs were low. These results highlight the importance of valuing the task for actualizing the benefits of feeling competent on academic achievement (and vice versa) but also highlight that perceiving costs may be disruptive to the relations between competence beliefs and achievement. However, a limitation of the study by Trautwein and colleagues was that the assessment of perceived cost included a two-item measure that collapsed effort cost ("I'd have to invest a lot of time to get good grades in mathematics/English") and opportunity cost ("I'd have to sacrifice a lot of free time to be good at mathematics/English"). While Guo and colleagues included different subcomponents of cost in their study, they only examined the interaction between self-concept and a general cost factor. Clearly, understanding the interactive effects of perceived competence and perceived cost on academic outcomes requires further research that attends to the multi-dimensionality of perceived costs (Flake et al., 2015; Gaspard et al., 2015; Perez et al., 2014) and that investigates these relations across educational levels and contexts.

1.3 The Current Study

In this study, we investigated how expectancy beliefs, sub-components of task values, and sub-components of perceived costs related to each other over time within a biology course over a single semester. We also examined the unique relations of perceived costs and academic achievement in the gateway biology course, controlling for expectancy beliefs and task values. Finally, we examined the moderating effect of perceived costs on the relations between expectancy beliefs and achievement. A particular strength of this study is that we include the three main sub-components of perceived cost via three separable subscales: effort cost, opportunity cost, and psychological cost (Eccles et al., 1983; Flake et al., 2015; Gaspard et al., 2015; Perez et al., 2014) in addition to the three main subcomponents of task value: attainment

value, interest value, and utility value. A benefit of examining subcomponents of values and costs is that there may be differential relations among these variables over time. For example, it is possible that utility value is a protective factor against perceiving higher costs in a course since valuing a course for meeting a long-term goal (e.g., a career goal) may make the costs worthwhile. However, interest in the course or domain may not have the same benefit. The answer to such questions may have implications for how to intervene within science courses. For example, a temporal link between utility value and percieved costs may suggest that utility value interventions could also reduce perceived costs. Finally, prior research highlights variable relations of the task value subcomponents to academic outcomes and to each other (see Trautwein et al., 2013). Thus, a key contribution of this study is that we examine the subcomponents of task values and costs and their interrelations.

The study had the following research questions and related hypotheses:

RQ1: What are the cross-lagged relations between expectancies, task values and perceived costs over a semester?

Given the limited and mixed research examining the temporal relations of expectancies, task values, and perceived costs, the potential relations among these variables over a semester are not completely clear. While some prior research and theory suggest competence beliefs shape task values (see Wigfield et al., 2009 for a brief review) other research suggests earlier task values may also predict later competence beliefs (Fryer & Ainley, 2017). Prior research and theory do clearly suggest the relations among expectancy beliefs and task values will be positive. However, given the mixed prior research, we make no hypotheses about the specific relations between expectancies and the different task values.

Hypothesis 1a: Expectancy beliefs and task values will positively relate to each other over time.

There is no prior empirical research that we are aware of that suggests the temporal relations between expectancy beliefs and task values to perceived costs. However, based on theory and cross-sectional correlations among these variables it stands to reason that

expectancies and task values may shape perceived costs and vice versa. However, these assertions are more exploratory given the lack of prior research. Theoretically, expectancy beliefs and values should be negatively related to perceived costs.

Hypothesis 1b: Expectancies and task values will negatively relate to perceived costs over time.

RQ2: What is the unique relation of each perceived cost component with biology achievement, controlling for task values and expectancy beliefs?

Based on theory and prior research we expected that expectancy beliefs would have the strongest relationship with achievement and that this relation would be positive. Furthermore, the few studies that have included both perceived costs and expectancy beliefs in predicting achievement have demonstrated mixed results. For example, Trautwein et al. (2012) found that perceived cost predicted English achievement while controlling for expectancies (and several other variables) yet cost no longer predicted math achievement after controlling for expectancies. Guo et al. (2016), on the other hand, found that cost predicted math achievement, controlling for self-concept and task values. In another study, Perez et al. (2014) found that perceived cost did not relate to undergraduate chemistry achievement when controlling for task values and expectancy beliefs. Thus, we did not make direct hypotheses about whether costs would relate to achievement above and beyond task values and expectancy beliefs.

Hypothesis 2a: Expectancy beliefs will positively relate to achievement and will be the strongest predictor of achievement relative to task values and perceived costs.

If there is a relationship between perceived cost and achievement, we expected that perceived costs would be negatively related to biology achievement based on theory and prior research (Guo et al., 2016; Trautwein et al., 2012).

Hypothesis 2b: Any relations between perceived costs and achievement in the course will be negative.

RQ3: Does perceived cost in biology moderate the relations between biology expectancy beliefs and biology achievement?

Finally, we expected perceived costs would moderate the relations between expectancy beliefs and academic achievement. We expected that high costs may impede the beneficial effects of high expectancy beliefs on academic achievement (Barron & Hulleman, 2015; Trautwein et al., 2013). In other words, we expected that achievement would be highest when expectancy beliefs are high and perceived costs are low (Guo et al., 2016). While such relations may vary by the type of perceived cost, there is little prior research to suggest what such differences might be. As such, we expected the pattern of effects to be similar across different costs but perhaps with variations in magnitude. Thus, the differences in the interactive effects of expectancy beliefs and different kinds of costs were exploratory.

Hypothesis 3: Perceived costs will moderate the relations between expectancy beliefs and achievement such that the relations between expectancy beliefs and achievement is strongest when perceived costs are low.

2. Method

2.1 **Participants**

Participants were 234 ethnically diverse undergraduate science students (M_{age} = 20.30 years, *SD* = 3.47) who were enrolled in one of three sections of an introductory biology course for science majors at a minority-serving institution in the mid-Atlantic United States. The sample was 76.1% female, 26.1% African American, 45.0% White, 14.0% Asian, 7.7% Hispanic/Latino, and 7.2% of the sample identified as “other” for race/ethnicity. The sample was a majority freshman or sophomore year students and 47.7% of participants were first-generation college students.

The course from which students were recruited was an introductory gateway cellular and molecular biology course. The course is required for several biological science majors at the institution including biology, biochemistry, biological oceanography, and marine biology. Students were enrolled in one of three course sections. The same teaching materials, assignments, and exams were used in all three sections of the course, which were all taught by the same instructor. We calculated an intraclass correlation (ICC) to determine if class section

related to final course grade. The ICC indicated that class section did not relate to final grade (ICC = .01). The course was a lecture-based course format, which included four during-semester exams and a final exam. Students from all three sections completed all course exams together and at the same time in a testing center. The course also included in-class assignments; however, performance on the four during-semester exams and final exam made up the largest percentage of the final grade in the course. Finally, there was a lab component that was a separate course from the lecture. Students received a separate grade for the biology lab.

2.2 **Procedure**

The data were collected as part of an intervention study in which participants were randomized within each course section to receive either 15 weekly e-mails with links to brief videos (~5 minutes) with a demonstration of a learning strategy (e.g., compare and contrast), or four e-mails with links to brief videos with a description of coping with a certain perceived cost (e.g., effort is worthwhile), or a combination of the two. However, the intervention did not show any effects whatsoever in this semester. Difference tests using both intent-to-treat and as-treated conditions resulted in no significant differences among the conditions in posttest expectancy beliefs, perceived costs, or biology course achievement (all $p > .05$). We also tested for various interaction effects between the conditions and other variables (e.g., interactions between first-generation status and conditions; interactions between URM status and conditions; interactions between sex and the conditions) and found no significant relations of these interactions to posttest expectancy beliefs, task values, perceived costs, or biology course achievement (all $p > .05$). Given prior research showing interactions between expectancy beliefs and motivational interventions on academic outcomes (e.g., Hulleman & Harackiewicz, 2009; Hulleman et al., 2010), we also tested the relations of interactions between expectancy beliefs and the conditions to final biology course achievement. The results of these analyses were also non-significant ($p > .05$). Given that the interventions had no effect on these variables, we analyzed data from all participants together as one group.

In fall 2016, after receiving informed consent from participants, we assessed their expectancy beliefs, task values, and perceived costs for the biology course in the first 2 weeks of a 15-week semester (Time 1). These surveys also included a demographics form. We administered a posttest (Time 2) with the same measures (less the demographics measure) in week 13 of the course.[1] All surveys were administered online via a study-specific Blackboard site, which was separate from the course Blackboard site. The surveys were not timed and could be completed from any computer with internet access. Participants received 1% extra course credit for completing the pre-tests and 1% extra course credit for completing the posttest measures. This study was approved by the institution's IRB.

2.3 **Measures.**

We assessed participants' expectancy beliefs, task values, and perceived costs in the biology course. With participant consent, we also collected final grades in the biology course. All survey items used a 6-point forced-choice Likert response scale. Higher scores on the items indicate greater endorsement of the measured construct. All measures demonstrated good to excellent internal-consistency reliability (see Table 1 for reliability coefficients). We used longitudinal confirmatory factor analysis (CFA) to test the construct validity of the measures and used guidelines from Hu and Bentler (1999) for assessing model fit in the CFA analyses. We tested for longitudinal measurement invariance for each of the variables. We used guidelines from Chen (2007) to examine configural and metric measurement invariance across time 1 and time 2 for each of the constructs. After obtaining evidence for longitudinal measurement invariance, we created variables by averaging item scores on the relevant scales. Details on each of the measures appear below and the full scales for each measure can be found in the Appendix.

---

[1] The participants also engaged with the intervention materials over the course of the semester, between the administration of the pretest and posttest. The intervention materials were either delivered weekly or one week prior to each of four exams depending on the condition. Students had one week to complete the intervention materials.

2.3.1 Expectancy beliefs

Biology perceived ability and expectancy beliefs were assessed with four of five items from Eccles and Wigfield (1995), which we adapted for the undergraduate biology course context. Two items measured expectations for success in the course (e.g., "How well do you think you will do in this biology course this semester?") and two items measured ability self-concept in the course (e.g., "How good are you at this biology course?"). A longitudinal CFA suggested an acceptable model fit for a single expectancy beliefs factor with fixed factor loadings across time; χ^2 (15) = 31.43, p = .007, RMSEA = .07, CFI = .99, SRMR = .04.[2]

2.3.2 **Task values**

We adapted 15 items from Eccles and Wigfield (1995) and Conley (2012) to assess three task values for the biology course including interest value, attainment value, and utility value. An example interest value item read, "I like this biology course." An example attainment value item was, "Being good at this biology course is an important part of who I am." Finally, an example utility value item read, "This biology course will be useful for me later in life." A longitudinal three-factor CFA with fixed factor loadings across time indicated an acceptable model fit supporting the construct validity of the scales (χ^2 [15] = 774.58, p < .001, RMSEA = .07, CFI = .94, SRMR = .06).

2.3.3 **Perceived costs**

We adapted 14 items from Perez et al. (2014) and Conley (2012) to assess three perceived costs for the biology course including effort cost, opportunity cost, and psychological cost. An example effort cost item read, "For me, taking this biology course might not be worth the effort." An example opportunity cost item was, "I have to give up a lot to do well in this biology course." Finally, an example psychological cost item read, "I'm concerned that my self-esteem will suffer if I am unsuccessful in this biology course." After dropping three poorly

---

[2] The errors for the two self-concept of ability items were correlated in the model due to their conceptual overlap.

performing items,[3] a longitudinal three-factor CFA with fixed factor loadings across time indicated an acceptable model fit that supported the construct validity of the three scales (χ^2 [15] = 358.44, $p < .001$, RMSEA = .06, CFI = .94, SRMR = .06).

2.3.4 **Final Biology Grade**

With participant consent, final grades in the biology course were collected from the course instructor at the end of the semester and before extra credit for participation in the study was applied. There were 560 total possible points in the course, including four during-semester lecture exams (4 ×100 points each), a final exam (100 points), and several homework assignments (60 points). Final biology grade was the proportion of the total points earned in the course and ranged from 0.00 to 1.03.[4]

2.4 **Data Analysis**

We used path modeling with observed variables in Mplus (v. 7.3) to examine our data. We used robust maximum likelihood estimation in all models (MLR). To examine RQ1 and RQ2, we tested a series of autoregressive cross-lagged path models examining the relations of expectancy beliefs, task values, and perceived costs from time 1 (T1) to time 2 (T2) and the unique association of T2 perceived costs with final biology grade (see Figure 1). Initially, each T2 variable was regressed on itself at T1 and all other T1 expectancy-value variables. We assumed the relations of T1 expectancy-value variables with final biology grade to manifest through the T2 motivation variables. In other words, we assumed T1 variables would not have a direct effect on final biology grade since the effect of the T1 variables on final grade would be

---

[3] Modification indices suggested one opportunity cost item and two psychological cost items should load onto other factors, which was negatively impacting overall model fit.

[4] The instructor offered a small portion of extra credit for lecture attendance that was independent of the extra credit earned for participating in the study. All students in the course were eligible to receive this extra credit. Therefore, some students earned greater than 100% of the possible points in the course.

captured indirectly through the relations of the T1 motivation variables with the T2 motivation variables.[5]

We used a model building approach by which we set non-significant regression paths in the first model to zero and used a chi-square difference test to compare the more parsimonious, nested model with the base model. This tested the first research question regarding the cross-lagged relations between expectancies, task values, and perceived costs. It also allowed us to estimate fewer parameters, which was beneficial given our relatively small sample size.

To test RQ3, we tested a model in Mplus (v. 7.3) using only the T2 expectancy-value variables since these variables were most proximal to the final grade variable and to simplify the model given our sample size. We fit a single model specifying each of the three cost variables as moderators of the relations between expectancy beliefs and final grade, controlling for the other three task values. We centered all variables in the model and we created two-way interaction variables directly in Mplus by multiplying the expectancy beliefs variable by each of the cost variables. This was a fully saturated model with 0 *df*. When results indicated a significant interaction, we examined the effect of expectancy beliefs on final grade at +1, 0, and -1 *SD* of the moderator to further explore the interaction.

2.4.1 **Missing data**

While approximately 14% of the sample had missing time 1 variables and 19% of the sample had missing responses at time 2 (67% of students had full data), Mplus uses full information maximum likelihood to handle missing data, which allowed us to use the full sample in our analyses.

3. Results

3.1 Descriptive Statistics and Correlations

---

[5] A model in which the T1 variables predicted final grade indicated that none of the T1 variables were significant predictors of final grade, accounting for the T2 predictors.

Descriptive statistics and correlation results for the variables are presented in Table 1 and Table 2, respectively. The correlations supported the theorized relations and the convergent and discriminant validity of the constructs. Expectancy beliefs at time 1 (T1) and time 2 (T2) were positively correlated with all task values at T1 and T2. Furthermore, expectancy beliefs at both time points were negatively correlated with all perceived costs at T1 and T2. All task values at T1 and T2 were negatively correlated with effort and opportunity costs at T1 and T2; however, task values and psychological costs were not significantly correlated with each other at either time point. All three perceived costs were significantly and positively correlated with each other at both time points. Furthermore, effort cost and opportunity costs typically had the strongest correlations with each other compared to correlations between these two perceived cost variables and psychological costs. Expectancy beliefs and task value variables at both time points were all positively correlated with final grade. All three perceived costs at both time points were negatively correlated with final grade. As expected, expectancies at T1 and T2 had the strongest correlation with final biology grade. Among the costs, effort cost had the strongest correlations with final grade, while opportunity and psychological costs had relatively weaker correlations with final grade.

3.2 RQ1: What are the cross-lagged relations between expectancies, task values, and perceived costs over a semester?

The initial cross-lagged path model (Model A), regressing final biology grade on all T2 motivation variables and regressing all T2 motivation variables on all T1 motivation variables, was an excellent fit to the data (see Table 3 for fit indices). The coefficients for this model can be found in Table S1 of the supplemental materials. Next, we fixed all non-significant regression coefficients to zero (Model B) and compared this more parsimonious model to the initial free-estimate model using the Satorra-Bentler chi-square different test (Satorra & Bentler, 2001). The results indicated that the more constrained model fit the data very well (see Table 3) and was not significantly different from the less constrained model ($\Delta\ \chi^2$ [62] = 55.47, $p > .05$). Therefore, we accepted Model B, the more constrained (and parsimonious) model, as reflecting the data. Figure

1 presents the coefficients for the final model. Table S2 of the supplemental materials provides the results for a model (Model B2) with all non-significant paths from Model A fixed to 0 but with the effects of the intervention freely estimated.

3.2.1 Predicting expectancy beliefs

Results from the final model indicated that the only statistically significant predictor of expectancy beliefs at T2 was T1 expectancy beliefs ($\beta = .61$, $p < .001$). The stability coefficient suggests the expectancy beliefs variable was relatively stable from T1 to T2.

3.2.2 Predicting task values

The final-model results indicated that, controlling for T1 attainment value, T1 expectancy beliefs and utility value were positively and significantly associated with T2 attainment value ($\beta = .18$, $p = .001$ and .26, $p = .003$, respectively) with T1 utility value having the stronger relation to T2 attainment value compared to expectancy beliefs. T1 expectancy beliefs were positively associated with T2 interest value ($\beta = .15$, $p = .013$). The only statistically significant relation to T2 utility value was T2 utility value ($\beta = .72$, $p < .001$). Based on the stability coefficients for the three task value variables, utility value was most stable from T1 to T2 followed by interest value ($\beta = .55$, $p = .001$) and attainment value ($\beta = .39$, $p = .001$).

3.2.3 Predicting perceived cost

The final model indicated that, T1 attainment value was negatively associated with T2 effort cost ($\beta = -.21$, $p = .005$) and opportunity cost ($\beta = -.18$, $p = .037$), controlling for T1 effort cost and opportunity cost, respectively. The only statistically significant relation to T2 psychological cost was T1 Psychological cost ($\beta = .40$, $p < .001$). Of the three perceived costs, psychological cost was most stable followed by effort cost ($\beta = .30$, $p < .001$) and opportunity cost ($\beta = .24$, $p < .001$). All three costs showed less stability than the other task values (with the exception of attainment value) and expectancy beliefs, suggesting other factors were influencing changes in cost perceptions from T1 to T2.

3.3 RQ2: What is the unique relation of each perceived cost component with biology achievement, controlling for expectancy beliefs and task values?

Results of the final model indicated that T2 expectancy beliefs (β = .64, $p < .001$) had the strongest relation to final biology grade, followed by effort cost (β = -.21, $p = .009$) and opportunity cost (β = .14, $p = .017$). These variables together explained 50% of the variance in final biology grade. None of the other variables were significantly related to final grade in the initial model. Surprisingly, the relation between opportunity cost and final biology grade was positive rather than negative. The correlation between T2 opportunity cost and final grade was negative ($r = -.18$) suggesting a suppression effect.

To further understand this result, we examined multicollinearity diagnostics in SPSS and examined correlations among the variables. While some correlations were high, none exceeded $r = .71$. Furthermore, the correlation between effort and opportunity cost was .68 at T1 and .61 at T2. Thus, the size of the correlations was not extreme. Furthermore, collinearity diagnostics did not indicate multicollinearity was an issue since the largest variance inflation factor (VIF) was 2.74, which is far below recommended cutoffs of 6.00 – 10.00 (Keith, 2015; Meyers, Gamst, & Guarino, 2013). Additional analyses indicated that the suppression effect likely resulted from the shared variance between opportunity cost, effort cost, and grades. The inclusion of effort cost together with opportunity cost has "cleaned" the shared variance reflecting negative relations between opportunity cost and grades, leaving some variance that indicates certain positive relations between these variables. This implies complex and potentially conflicting processes underlying the relations of opportunity cost and grades. However, these findings should be interpreted with caution and requires further research.[6]

3.4 RQ3: Do expectancy beliefs moderate the relations between perceived cost and final grade?

---

[6] We analyzed a model in which we dropped effort cost and found that opportunity cost was no longer significantly related to final biology grade. However, in a model where we dropped opportunity cost, effort cost remained negatively related to final biology grade.

Results of the moderation analysis model indicated significant relations between the T2 expectancy × effort cost interaction variable and final biology grade (b = -.02, p =.002)., controlling for task values and the other expectancy × cost interaction variables (see Figure 2). Simple slopes analysis probing this interaction indicated that the strength of the relationship between expectancy beliefs and final grade changed at different levels of effort cost. Specifically, the relationship between expectancy beliefs and final grade was strongest when effort cost was low (b = .11, p < .001) and was weakest when effort cost was high (b = .06, p < .001; see Figure 3). Controlling for all interactions and T2 task values, the expectancy × opportunity cost (b = .002, p = .689) and expectancy × psychological cost (b = -.003, p = .504) interactions were not significantly related to final biology grade.

4. Discussion

Our study adds to existing research on the role of cost perceptions in science achievement and on the temporal relations of key expectancy-value constructs within the context of an undergraduate introductory biology course. First, we fill a gap in the motivation literature by examining the interrelations of biology undergraduates' expectancies, task values, and perceived costs to understand how these variables are shaped within a semester. Most prior research has examined these interrelations over longer periods with K-12 students and none have included perceived costs. Second, we fill a gap on the unique main effects of different perceived costs on achievement in a STEM discipline, accounting for the other expectancy-value variables. The unique role of the different perceived cost, task value, and competence belief variables are important to understand yet have rarely been examined in a comprehensive model (Trautwein et al., 2013). Finally, we examined the moderating effect of the perceived cost subcomponents on the relations between expectancy beliefs and science achievement. Again, such analyses have rarely been conducted and can contribute to understanding the interplay of the different motivational processes included in expectancy-value theory (Barron & Hulleman, 2015; Trautwein et al., 2013), as well as the more general mechanisms by which motivation affects

achievement in STEM disciplines. Next, we discuss these findings and their implications for theory and future research.

4.1 Temporal Relations Among Expectancies, Task Values, and Perceived Costs

In interpreting the temporal relations among the expectancy-value variables, we first consider the stability of the expectancy-value constructs over time. It was interesting that generally, based on the stability coefficients, the expectancy beliefs ($\beta = .61$) and task value variables ($\beta = .40$ to $.72$) demonstrated greater stability over time than the cost variables ($\beta = .24$ to $.40$). The one exception was attainment value ($\beta = .40$), which had a similar stability coefficient to psychological cost. These results suggest the cost variables, relative to expectancy beliefs or task values, may be more sensitive to feedback within the course and also more malleable through intervention.

Beyond the stability of the variables, the final autoregressive cross-lagged path model suggested that expectancy beliefs, task values, and perceived costs are shaped by each other over the course of a semester; however, the results varied by construct. Consistent with some prior research (Wigfield et al., 2009), we found that while expectancy beliefs were related to some of the task values, none of the task values related to expectancy beliefs. This finding suggests that, in the short term, attainment value and interest value at the end of the semester seem to be affected by expectancy beliefs at the beginning of the semester, but that utility value seems to be unrelated to expectancy beliefs. Thus, it seems that early perceived competence in the domain may frame students' later development of interest in and sense of importance of the domain, but is unrelated to their perceived usefulness of the biology course for their future goals. This suggests that, in the context of this biology course, differing processes underlie the different task values. In addition, utility value at the beginning of the semester partially related to the development of attainment value at the end of the semester, suggesting that perceived relevance of the course for future goals is related to enhanced perceptions of the importance of the course for one's identity. This finding is consistent with the role of one's future career goals in one's personal and collective identity (Eccles, 2009).

Perceived costs, in turn, seem to be shaped by attainment value but not by the other values or by expectancy beliefs in the course at the beginning of the semester. We know of no other research examining the temporal effects of expectancy beliefs and task values on perceived costs (and vice versa). This study suggests that attainment value may be most important among the expectancy-value constructs in shaping perceived costs in the context of a gateway biology course at a large public and diverse university. However, this was only the case for effort costs and opportunity costs. It may be that, in this context, the importance of a task to one's identity affects whether students perceive a task as too effortful or resulting in lost opportunities. This is in line with theory (Oyserman & Destin, 2010) that suggests that when a task aligns with one's identity, the effort for the task will be perceived as an indication of the task's value. However, if the task is not aligned with one's identity, then the effort required for the task will be perceived as a cost. While more research is needed to further support these possibilities, particularly in different contexts (e.g., different domains of study and with different age groups), a benefit of this study is that we were able to highlight this possibility by examining temporal relations among the different values and costs subcomponents. Further, an important implication of these findings is that enhancing attainment value may lead to reduced cost perceptions in an undergraduate science course. Thus, attainment value may be an important construct to target for intervention in such courses. Few motivation interventions target attainment value specifically (Rosenzweig & Wigfield, 2016); thus, there are opportunities for future research in this area.

4.2 Main Effects of Perceived Cost on STEM Achievement

Results suggested that, after controlling for other expectancy-value variables, only time 2 expectancy beliefs, effort costs, and opportunity costs were related to final grade in the biology course. These findings align with prior research on the role of expectancy beliefs in achievement but also contradict some research when it comes to the relations of perceived cost with achievement (Perez et al., 2014). Our findings of significant relations between perceived costs and final biology course grade are different from the findings of Perez and colleagues, who did not find such relations with chemistry grades. Notably, the perceived costs items used by Perez

et al. targeted the STEM major whereas the items in the current study focused on the biology course, and therefore aligned better with the unit-of-analysis of the course grade outcome, potentially explaining the difference in findings. Still, these results are intriguing given the theoretical prediction that perceived costs would be less important for achievement than for academic choices, while expectancy beliefs would be more related to achievement (Eccles et al., 1983). In our study, effort cost and opportunity cost were related to final biology grade even after controlling for expectancy beliefs, suggesting unique relations. These results are consistent with some prior research (Guo et al., 2016) and add to prior research by highlighting which particular costs are related to achievement. However, as we emphasize in the results section, the findings for the association of opportunity cost and achievement suggest complex relations, which should be interpreted with caution and require unpacking in future research. The relations of effort cost with final grade seem more robust. As expected, expectancy beliefs had the strongest relationship with final grade. Overall, these findings suggest that, for the students in this study, both perceived confidence and perceived costs–particularly perceived effort cost–for the course are important for course achievement. These findings, however, need to be considered in light of the significant interactions we found between perceived costs and expectancy in relation to achievement, on which we elaborate in the next section.

4.3 Perceived Costs as a Moderator of the Relations between Expectancy Beliefs and Biology Achievement

A primary aim of this study was to examine the moderating effect of perceived costs on the relations between expectancy beliefs and achievement. The findings suggest that, in the current sample, such moderation by perceived costs was present but only with effort cost, controlling for task values, expectancy beliefs, and the other expectancy × cost interaction variables. Consistent with theoretical predictions (Eccles et al., 1983; Barron & Hulleman, 2015), the strength of the relations between expectancy beliefs and achievement varied by effort cost. At high effort cost, the relation between expectancy beliefs and achievement in the course was weaker than the relation between expectancy beliefs and achievement at low effort cost, suggesting that

perceiving effort costs in the course may disrupt the benefits of high expectancies for achievement. In other words, the relations of expectancy beliefs with academic achievement in this undergraduate biology course depended on students' perceptions about whether the effort required in the course was worthwhile. It is possible that, despite feeling competent in the course, students with higher effort costs disengage with the content or engage in maladaptive behaviors. Findings from Jiang and colleagues (Jiang et al., 2018) that higher costs are associated with maladaptive outcomes supports this premise. A combination of high expectancies of success in the course with high effort costs may also serve as an indicator of concern about the calibration of their high expectancy beliefs with course demands, or about a possible difference between their interpretation of the standard of success as assessed in the expectancy and the perceived cost measures. The perceptions of effort costs may be an indicator that students have been experiencing a struggle in the course despite their high expectancy beliefs. These findings are similar to findings in the few other studies in which the interaction effects of competence beliefs and perceived costs was examined (Guo et al., 2016; Trautwein et al., 2012). For example, Trautwein and colleagues (2012) found similar patterns of interactions between expectancy beliefs and perceived cost in explaining both math and English achievement in a study with German high school students. In their study, the pattern of interactions revealed that achievement in both math and English was highest when expectancy beliefs were high and costs were low. Our study adds to these findings by using more differentiated measures of perceived cost and corroborating these findings with effort cost. Furthermore, this study adds to the very limited prior research examining these relations.

4.4 Limitations

There are limitations that should be considered when interpreting these findings. First, while we did not find differences between the intervention groups on the motivation or outcome variables (or interaction effects of the intervention with baseline or demographic variables), it is still possible that there is a more dynamic interplay among the variables that the interventions affected (e.g., a three-way interaction between baseline motivation, demographic variables, and

the intervention). Nevertheless, the current findings are consistent with prior research (e.g., Guo et al., 2016; Trautwein et al., 2012) and the effects in a similar model that freely estimated the effects of the intervention conditions were very similar to those that did not control for the intervention (see Table S2), suggesting that the findings hold regardless of any undetected intervention effect.

Second, our results included a suppression effect on opportunity cost. While the expectancy beliefs, task values, and perceived costs variables are theoretically distinct and separate in a factor analyses, they are interrelated (as demonstrated in this study). Such relations can lead to difficulties for variable-centered statistical analyses. Person-oriented analyses such as latent profile analysis or cluster analysis may offer an alternative approach to examining the relations of these variables in combination without similar multicollinearity issues. However, a limitation of such person-oriented approaches is that questions asked in this study about the unique interrelations of these variables cannot be examined. Further research is needed to confirm these findings and to further explore how the interrelations of expectancies, values, and costs affect academic outcomes in various STEM disciplines.

Third, our sample size was somewhat small for estimating the various parameters in our models. As a result, some interrelations may not have been detected due to lack of power. The sample size also limited our ability to test latent interactions in our models, which would have allowed us to model the error in our analyses and, therefore, reduce the error in our interaction terms (Trautwein et al., 2013). Unfortunately, the size of the courses at study site limited our potential sample size. Even so, we were able to detect several interesting relations among the variables, including the interaction between expectancy beliefs and effort cost. These relations should continue to be examined in future research with larger samples. For example, with a larger sample, it may be more feasible to also model interactions between perceived costs and values in a single model. The moderating role of perceived costs in the relations between values and academic outcomes remains an underexplored, yet important question for future research (Barron & Hulleman, 2015; Trautwein et al., 2013).

Fourth, there are important open questions with regard to the operationalization of various kinds of costs, the dimensions of cost, and which perceived costs are most relevant in different disciplines. Additionally, some scholars have identified additional subcomponents of attainment and utility value (e.g. Gaspard et al., 2015), which we did not include in our study. It is possible that more nuanced subcomponents of value may have differential effects on different perceived costs. Unfortunately, we were unable to address such questions in this study. However, our study contributes to the literature since there has been little research examining the multiple subcomponents of values and costs together. Our results highlight differential relations between different subcomponents of the values and costs included in this study. Future research should assess the various costs using the different cost measures within the same study to determine the overlap and distinction of the various cost constructs (e.g., ego cost vs. emotional cost vs. psychological cost). Future research may also include the further subcomponents of value to determine if differential relations are found for these more nuanced facets of task value.

Finally, it is important to note that we cannot make causal claims from our analyses. Rather than motivation causing achievement, there is likely a reciprocal relationship over the course of the semester between achievement in the course and motivation in the course (e.g., Perez et al., 2014). Future studies should employ methods that can examine these dynamic relations over time.

4.5 Implications

While there are limitations to this study, the study does have important implications for expectancy-value theory and future research in STEM. First, the interactive effects found here support the hypothesis that expectancy beliefs and perceived costs variables interact to affect achievement in science (Barron & Hulleman, 2015). Importantly, in the context of an undergraduate introductory biology course, the association of expectancy beliefs with achievement in science may depend on individual characteristics of the students, such as variations in levels of perceived effort cost. Thus, the relations of these variables with achievement outcomes may not only be additive, but they may also be multiplicative (Nagengast

et al., 2011; Trautwein et al., 2012). Second, expectancy beliefs are important to consider as a lever for interventions designed to increase science achievement but so are perceived costs. In introductory biology courses, mitigating perceived costs may be particularly important for students with high expectations for success/ability beliefs in biology, since the results of this study suggest that perceiving effort costs negatively affects biology achievement for these students. Finally, perceived costs seem to be related to attainment value in particular, suggesting that identity-related processes may be involved in the formation of effort and opportunity costs within a semester. Thus, intervening on the importance of science to students' identity early in the semester in introductory science courses may help to ameliorate the perceived effort and opportunity costs in the course.

4.6 Conclusion

In this study, and in the context of a gateway biology course, we examined the unique relations of perceived costs with achievement in the course, the temporal interrelations of expectancy beliefs, task values, and perceived costs with each other, and, importantly, the role of perceived costs as a moderator of the relations between expectancy beliefs and course achievement. The results of this study contribute to expectancy-value theory and STEM research by suggesting that some costs may be shaped by identity-related processes in science courses. Furthermore, the relations of expectancy beliefs with achievement in a gateway biology course may depend on students' perceived effort costs for the course. The results of the expectancy × effort cost interaction effects found here were consistent with prior research but also extend prior research by examining such interactions with three different kinds of perceived costs. More research is needed to corroborate and to investigate in-depth the interplay of different types of perceived costs as important components in students' success across various STEM disciplines.

References

Acee, T. W. & Weinstein, C. E. (2010). Effects of a value-reappraisal intervention on statistics students' motivation and performance. *Journal of Experimental Education, 78*(4), 487-512. doi: 10.1080/00220970903352753

Barron, K. E., & Hulleman, C. S. (2015). Expectancy-value-cost model of motivation. In J. S. Eccles & K. Salmelo-Aro (Eds.), *International encyclopedia of social and behavioral sciences, 2nd Edition: Motivational psychology* (pp. 261–271). Amsterdam, Netherlands: Elsvier.

Battle, A., & Wigfield, A. (2003). College women's value orientations toward family, career, and graduate school. *Journal of Vocational Behavior, 62*(1), 56-75. doi: 10.1016/S0001-8791(02)00037-4

Bong, M. (2001). Between- and within-domain relations of academic motivation among middle and high school students: Self-efficacy, task value, and achievement goals. *Journal of Educational Psychology, 93*(1), 23-34. http://dx.doi.org/10.1037/0022-0663.93.1.23

Chen, J. A., Tutwiler, M. S., Metcalf, S. J., Kamarainen, A., Grotzer, T., & Dede, C. (2016). A multi-user virtual environment to support students' self-efficacy and interest in science: A latent growth model analysis. *Learning and Instruction*, *41*, 11-22.

Chen, A., & Liu, X. (2009). Task values, cost, and choice decisions in college physical education. *Journal of Teaching in Physical Education, 28*(2), 192-213. doi: 10.1123/jtpe.28.2.192

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling, 14*(3), 464-504. https://doi.org/10.1080/10705510701301834

Chow, A., Eccles, J. S., & Salmela-Aro, K. (2012). Task value profiles across subjects and aspirations to physical and IT-related sciences in the United States and Finland. *Developmental Psychology, 48*(6), 1612-1628. doi: 10.1037/a0030194

Conley, A. M. (2012). Patterns of motivation beliefs: Combining achievement goal and expectancy-value perspectives. *Journal of Educational Psychology, 104*(1), 32-47. http://dx.doi.org/10.1037/a0026042

Cromley, J. G., **Perez, T.**, & Kaplan, A. (2016). Undergraduate STEM achievement and retention: Cognitive, motivational, and institutional factors and solutions. *Policy Insights from the Behavioral and Brain Sciences*, *3*(1), 4-11. doi:10.1177/2372732215622648

Dever, B. V. (2016). Using the expectancy-value theory of motivation to predict behavioral and emotional risk among high school students. *School Psychology Review, 45*(4), 417-433. https://doi.org/10.17105/SPR45-4.417-433

Durik, A. M., Vida, M., & Eccles, J. S. (2006). Task values and ability beliefs as predictors of high school literacy choices: A developmental analysis. *Journal of Educational Psychology, 98*(2), 382-393. http://dx.doi.org/10.1037/0022-0663.98.2.382

Eccles, J. S. (1987). Gender roles and women's achievement-related decisions. *Psychology of Women Quarterly, 11*(2), 135-172.

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist, 44*(2), 78-89. https://doi.org/10.1080/00461520902832368

Eccles, J. S., Adler, T., F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.),

Achievement and achievement motives: Psychological and sociological approaches (pp. 75–146). San Francisco, CA: W. H. Freeman and Company.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: The structure of adolescents' achievement task values and expectancy-related beliefs. *Personality and Social Psychology Bulletin*, *21*(3), 215-225.

Flake, J. K., Barron, K. E., Hulleman, C., McCoach, B. D., & Welsh, M. E. (2015). Measuring cost: The forgotten component of expectancy-value theory. *Contemporary Educational Psychology, 41*, 232-244. https://doi.org/10.1016/j.cedpsych.2015.03.002

Fryer, L. K., & Ainley, M. (2017). Supporting interest in a study domain: A longitudinal test of the interplay between interest, utility-value, and competence beliefs. *Learning and Instruction*. https://doi.org/10.1016/j.learninstruc.2017.11.002

Fryer, L. K., Ainley, M., & Thompson, A. (2016). Modelling the links between students' interest in a domain, the tasks they experience and their interest in a course: Isn't interest what university is all about? *Learning and Individual Differences, 50*, 157-165.

Gaspard, H., Wigfield, A., Jiang, Y., Nagengast, B., Trautwein, U., & Marsh, H. W. (2018). Dimensional comparisons: How academic track students' achievements are related to their expectancy and value beliefs across multiple domains. *Contemporary Educational Psychology, 52,* 1-14.

Gaspard, H., Dicke, A.-L., Flunger, B., Schreier, B., Häfner, I., Trautwein, U., & Nagengast, B. (2015). More value through greater differentiation: Gender differences in value beliefs about math. *Journal of Educational Psychology, 107*(3), 663-677. http://dx.doi.org/10.1037/edu0000003

Guo, J., Nagengast, B., Marsh, H. W., Kelava, A., Gaspard, H., Brandt, H., Cambria, J., Flunger, B., Dicke, A., Häfner, I. & Brisson, B. (2016). Probing the unique contributions of self-concept, task values, and their interactions using multiple value facets and multiple academic outcomes. *AERA Open*, *2*(1), https://doi.org/10.1177/2332858415626884.

Guo, J., Parker, P. D., Marsh, H. W., & Morin, A. J. S. (2015). Achievement, motivation, and educational choices: A longitudinal study of expectancy and value using a multiplicative perspective. *Developmental Psychology, 51*(8), 1163-1176. http://dx.doi.org/10.1037/a0039440

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1-55. https://doi.org/10.1080/10705519909540118

Hulleman, C. S., & Harackiewicz, J. M. (2009). Promoting interest and performance in high school science classes. *science*, *326*(5958), 1410-1412.

Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology, 102*(4), 880-895. http://dx.doi.org/10.1037/a0019506

Hurtado, S., Newman, C. B., Tran, M. C., & Chang, M. J. (2010). Improving the rate of success for underrepresented racial minorities in STEM fields: Insights from a national project. *New Directions for Institutional Research*, *2010*, 5-15. doi: 10.1002/ir.357

Jacobs, J. E., Lanza, S., Osgood, D. W., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: Gender and domain differences across grades one through twelve. *Child Development, 73*(2), 509-527.

Jiang, Y., Rosenzweig, E. Q., & Gaspard, H. (2018). An expectancy-value-cost approach in predicting adolescent students' academic motivation and achievement. *Contemporary Educational Psychology*, 54, 139-152.

Keith, T. Z. (2015). *Multiple regression and beyond: An introduction to multiple regression and structural equation modeling*. New York, New York: Routledge.

Kosovich, J. J., Flake, J. K., & Hulleman, C. S. (2017). Short-term motivation trajectories: A parallel process model of expectancy-value. *Contemporary Educational Psychology, 49*, 130-139.

Luttrell, V. R., Callen, B. W., Allen, C. S., Wood, M. D., Deeds, D. G., & Richard, D. C. (2010). The mathematics value inventory for general education students: Development and initial validation. *Educational and Psychological Measurement, 70*(1), 142-160.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*(1), 60-70. http://dx.doi.org/10.1037/0022-0663.82.1.60

Nagengast, B., Marsh, H. W., Scalas, L. F., Xu, M. K., Hau, K. T., & Trautwein, U. (2011). Who took the "×" out of expectancy-value theory? A psychological mystery, a substantive-methodological synergy, and a cross-national generalization. *Psychological Science, 22*(8), 1058-1066.

National Academies of Sciences, Engineering, and Medicine. (2017). *Supporting students' college success: The role of assessment of intrapersonal and interpersonal competencies*. Washington, DC: The National Academies Press. https://doi.org/10.17226/24697.

Neuville, S., Frenay, M., & Bourgeois, E. (2007). Task value, self-efficacy and goal orientations: Impact on self-regulated learning, choice and performance among university students. *Psychologica Belgica, 47*(1), 95-117. http://doi.org/10.5334/pb-47-1-95

Nuutila, K., Tuominen, H., Tapola, A., Vainikainen, M. P., & Niemivirta, M. (2018). Consistency, longitudinal stability, and predictions of elementary school students' task interest, success expectancy, and performance in mathematics. *Learning and Instruction, 56*, 73-83.

Meyers, L. S., Gamst, G., & Guarino, A. J. (2016). *Applied multivariate research: Design and interpretation*. Thousand Oaks, California: Sage Publications, Inc.

Oyserman, D., & Destin, M. (2010). Identity-based motivation: Implications for intervention. *The Counseling Psychologist, 38*(7), 1001-1043.

Perez, T., Cromley, J. G., & Kaplan, A. (2014). The role of identity development, values, and costs in college STEM retention. *Journal of Educational Psychology, 106*(1), 315-309. doi: 10.1037/a0034027

Perez, T., Wormington, S. V., Barger, M. M., Schwartz-Bloom, R. D., Lee, Y., & Linnenbrink-Garcia, L. (2019). Science expectancy, value, and cost profiles and their proximal and distal relations to undergraduate STEM persistence. *Science Education, 103*(2) 264-286. https://doi-org.proxy.lib.odu.edu/10.1002/sce.21490

Rosenzweig, E. Q., & Wigfield, A. (2016). STEM motivation interventions for adolescents: A promising start, but further to go. *Educational Psychologist, 51*(2), 146-163.

Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika, 66*(4), 507-514.

Seymour, E., Hewitt, N. (1997). *Talking about leaving*. Boulder, CO: Westview Press.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42*(1), 70-83. http://dx.doi.org/10.1037/0012-1649.42.1.70

Sullins, E. S., Hernandez, D., Fuller, C., & Tashiro, J. S. (1995). Predicting who will major in a science discipline: Expectancy–value theory as part of an ecological model for studying academic communities. *Journal of Research in Science Teaching, 32*(1), 99-119. doi: 10.1002/tea.3660320109

Trautwein, U., Marsh, H. W., Nagengast, B., Lüdtke, O., Nagy, G., & Jonkmann, K. (2012). Probing for the multiplicative term in modern expectancy–value theory: A latent interaction modeling study. *Journal of Educational Psychology, 104*(3), 763-777. http://dx.doi.org/10.1037/a0027470

Trautwein, U., Nagengast, B., Marsh, H. W., Gaspard, H., Dicke, A.-L., Lüdtke, O., & Jonkmann, K. (2013). Expectancy-Value Theory revisited: From Expectancy-Value Theory to Expectancy-ValueS Theory? In D. M. McInerney, H. W. Marsh, R. G. Craven, & F. Guay (Eds.), *International advances in self research. Theory driving research: New wave perspectives on self-processes and human development* (pp. 233-249). Charlotte, NC: IAP Information Age Publishing.

Watt, H. M. (2006). The role of motivation in gendered educational and occupational trajectories related to maths. *Educational Research and Evaluation, 12*(4), 305-322. https://doi.org/10.1080/13803610600765562

Watt, H. M. G., Shapka, J. D., Morris, Z. A., Durik, A. M., Keating, D. P., & Eccles, J. S. (2012). Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: A comparison of samples from Australia,

Canada, and the United States. *Developmental Psychology, 48*(6), 1594-1611. http://dx.doi.org/10.1037/a0027838

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review*, *30*(1), 1–35. https://doi.org/10.1016/j.dr.2009.12.001

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology, 25*(1), 68-81. http://dx.doi.org/10.1006/ceps.1999.1015

Wigfield, A., Tonks, S., & Klauda, S. L. (2009). Expectancy-value theory. In K. R. Wenzel & A. Wigfield (Eds.), *Educational psychology handbook series. Handbook of motivation at school* (pp. 55-75). New York: Routledge/Taylor & Francis Group.

Table 1

Descriptive Statistics for Variables

	N	*M*	*SD*	Skew	Kurtosis	α
Expectancy T1	202	4.28	0.76	-0.59	0.99	.90
Attainment T1	202	4.95	0.74	-0.68	0.29	.76
Interest T1	202	4.46	1.03	-0.90	1.03	.96
Utility T1	202	5.09	1.08	-1.43	1.72	.95
Eff. Cost T1	202	2.34	1.02	0.74	0.44	.81
Opp. Cost T1	202	2.69	1.14	0.58	0.04	.89
Psy. Cost T1	202	3.31	1.43	-0.03	-1.05	.85
Expectancy T2	189	3.96	1.04	-0.57	0.26	.95
Attainment T2	188	4.74	0.90	-1.09	1.29	.78
Interest T2	189	4.39	1.16	-0.89	0.33	.97
Utility T2	189	4.92	1.19	-1.38	1.42	.95
Eff. Cost T2	189	2.58	1.15	0.74	0.12	.83
Opp. Cost T2	189	2.84	1.22	0.44	-0.65	.89
Psy. Cost T2	188	3.34	1.37	0.02	-0.94	.86
Bio Grade	230	0.79	0.14	-0.45	-0.25	–

Note. T1 = Time 1; T2 = Time 2; Eff. Cost = Effort Cost, Opp. Cost = Opportunity Cost, Psy. Cost = Psychological Cost, Bio Grade = Final Biology Grade, α = Cronbach's Alpha.

Table 2

Bivariate Pearson Correlation Results

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Expectancy T1	–													
2. Attainment T1	.43	–												
3. Interest T1	.52	.64	–											
4. Utility T1	.41	.61	.56	–										
5. Eff. Cost T1	-.35	-.35	-.33	-.26	–									
6. Opp. Cost T1	-.29	-.25	-.26	-.26	.68	–								
7. Psy. Cost T1	-.36	.01	-.09	-.06	.36	.40	–							
8. Expectancy T2	.64	.29	.34	.27	-.30	-.24	-.25	–						
9. Attainment T2	.45	.62	.49	.57	-.27	-.22	-.08	.46	–					
10. Interest T2	.43	.41	.62	.37	-.23	-.18	-.10[a]	.63	.64	–				
11. Utility T2	.29	.44	.40	.71	-.19	-.19	-.04	.36	.68	.57	–			
12. Eff. Cost T2	-.20	-.32	-.24	-.21	.38	.26	.11	-.37	-.51	-.41	-.41	–		
13. Opp. Cost T2	-.18	-.20	-.17	-.16	.28	.36	.23	-.29	-.31	-.28	-.25	.61	–	
14. Psy. Cost T2	-.13	.05	.01	.06	.14	.15	.44	-.30	-.07	-.14	-.06	.32	.51	–
15. Bio Grade	.43	.23	.25	.20	-.23	-.16	-.15	.68	.36	.45	.28	-.36	-.18	-.19

Note. $N = 234$; T1 = Time 1; T2 = Time 2; Eff. Cost = Effort Cost, Opp. Cost = Opportunity Cost, Psy. Cost = Psychological Cost, Bio Grade = Final Biology Grade; all correlations > |.10| were statistically significant ($p < .01$). [a]$p = .026$

Table 3

Model Fit Results

Model	χ^2	*df*	Scaling correction	$\Delta\chi^2$	Δ *df*	CFI	RMSEA	SRMR
Model A	6.36	7	1.0699	–	–	1.00	.00	.01
Model B	61.84	69	1.0284	55.47[+]	62	1.00	.00	.04

Note. Model A includes all regression paths from time 1 motivation to time 2 motivation and from time 2 motivation to final biology grade freely estimated; Model A also includes freely estimated paths from the intervention conditions to time 2 motivation and final biology grade. Model B is the trimmed model with all non-significant paths in Model A fixed to 0.

[+] Satorra-Bentler scaled chi-square difference test

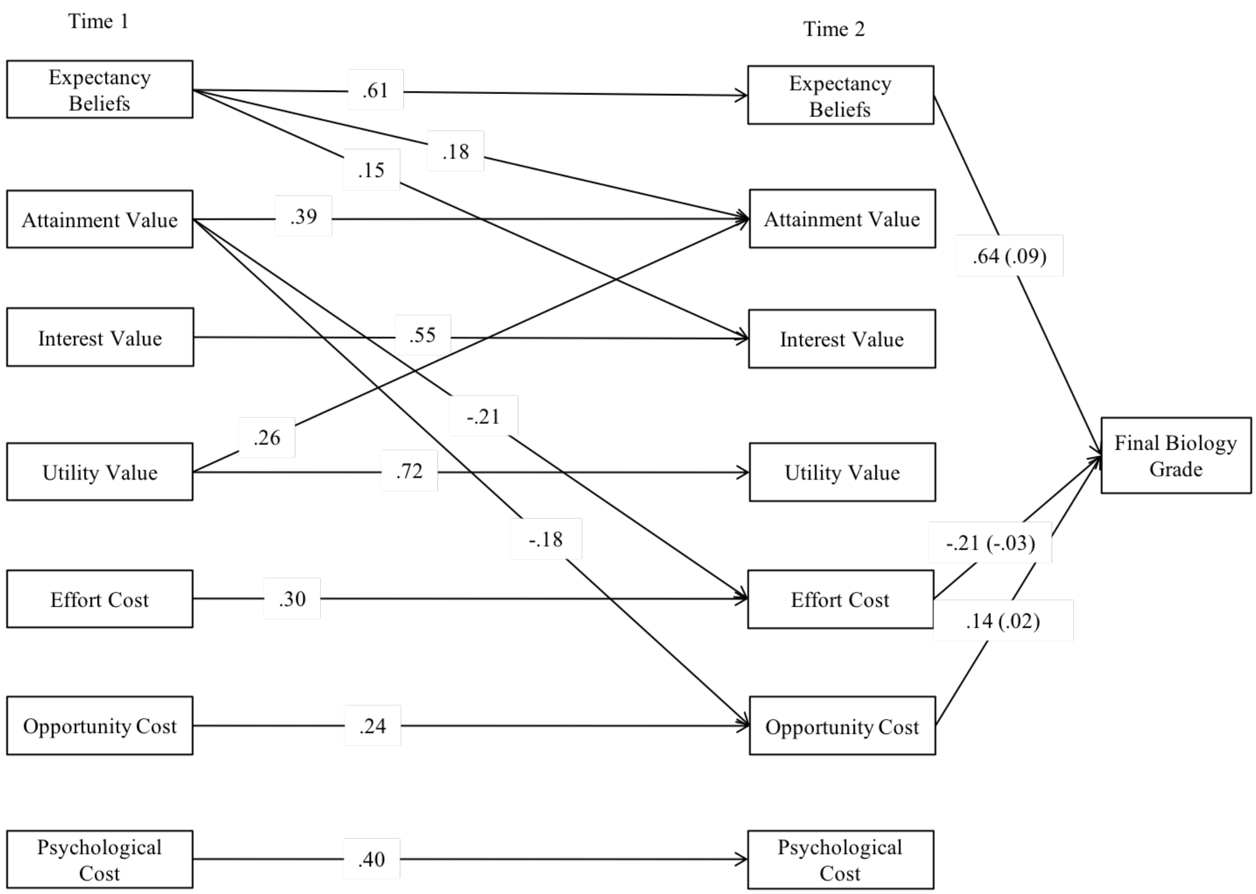

Figure 1. Model B Autoregressive Cross-lagged Path Model; Model B is the final model after fixing non-significant paths from Model A to 0; only statistically significant paths are presented. The intervention conditions were also included in Model B with their regression paths fixed to 0 since the conditions were not related to any variables in Model A. Coefficients are standardized; coefficients in parenthesis from time 2 motivation to final biology grade are unstandardized coefficients and represent the percentage point increase in final grade for a one unit increase in the motivation variable. Correlations for the time 1 variables were estimated as were correlations among the residuals of the time 2 variables; however, these are not depicted for clarity of presentation of the figure.

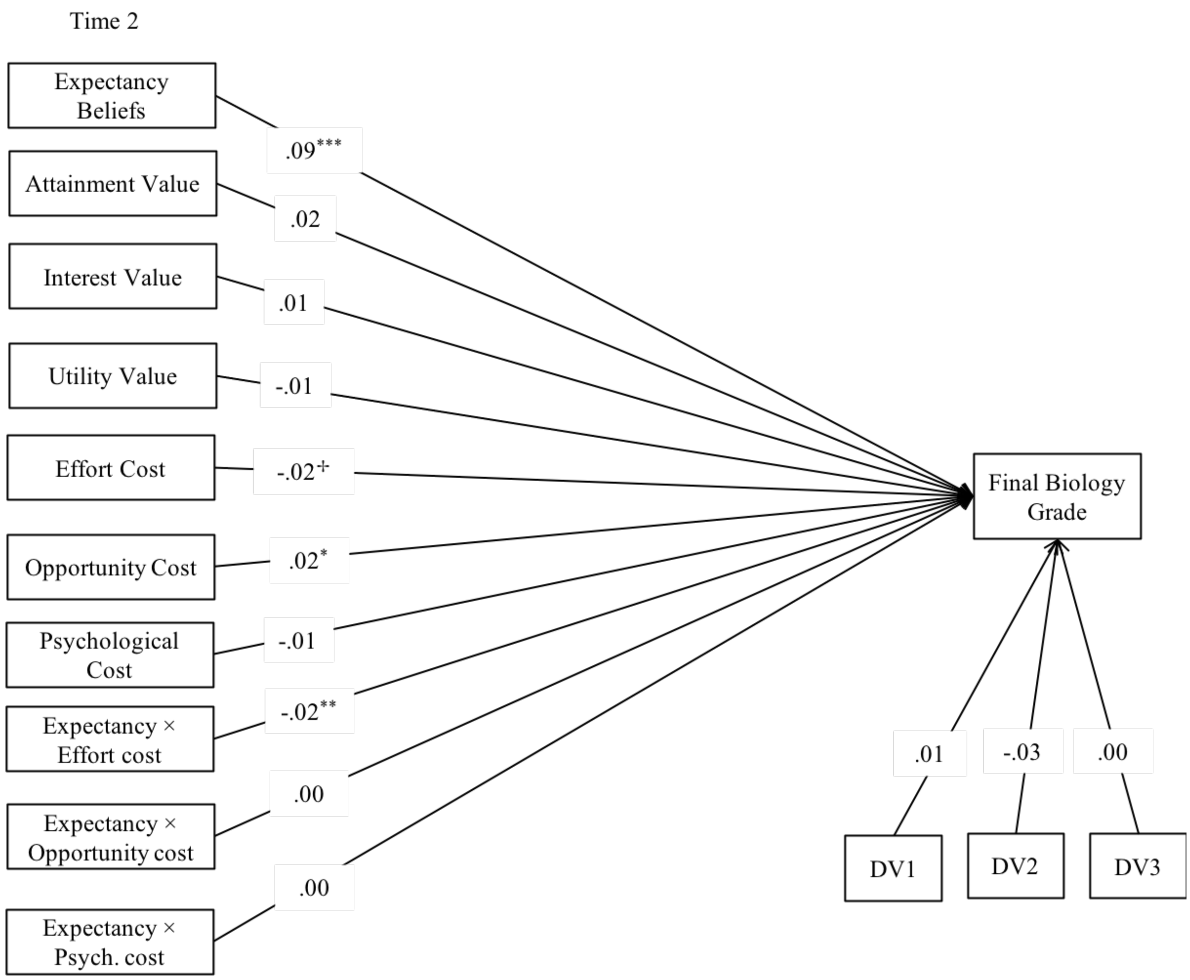

Figure 2. Interaction effects model; correlations for the time 2 variables were estimated but are not depicted for clarity of presentation of the figure; DV1 – 3 are the dummy variables for the experimental conditions; all coefficients are non-standardized coefficients.

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

$^{+}p = .054$

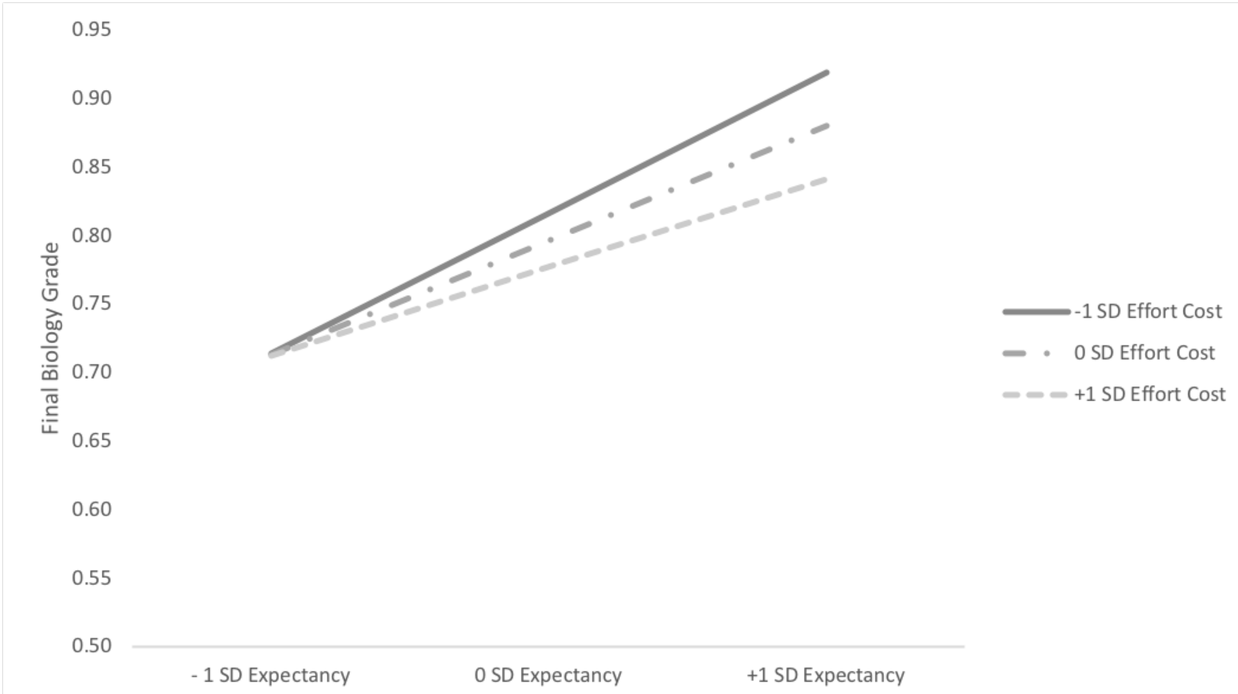

Figure 3. Conditional effects of effort cost on the relationship between expectancy beliefs and final grade; all slopes are statistically significant at $p < .001$.

Appendix

All items used a 1 – 6 point scale

Expectancy/Ability Beliefs Items

1. Compared to other students, how well do you expect to do in this biology course this semester? (Much worse than other students, Much better than other students)
2. How well do you think you will do in this biology course this semester? (Very poorly, Very well)
3. How good are you at this biology course? (Not at all good, Very good)
4. If you were to order all of the students in this biology course from the worst to the best in biology, where would you put yourself? (The worst, The best)

Attainment Value

1. I feel that, to me, being good at solving problems in this biology course is (Not at all Important, Very Important)
2. Compared to other courses, how important is it to you to do well in this biology course? (Not at all Important, Very Important)
3. Being someone who is good at this biology course is important to me. (Strongly agree, Strongly disagree)
4. Being good at this biology course is an important part of who I am. (Strongly agree, Strongly disagree)

Interest Value

1. How interesting do you find this biology course? (Very boring, Very interesting)
2. In general, I find working on assignments/studying for this biology course (Very boring, Very interesting)
3. Compared to other courses, how much do you like this biology course? (Dislike very much, Like very much)
4. I am fascinated by this biology course. (Strongly agree, Strongly disagree)
5. I enjoy this biology course. (Strongly agree, Strongly disagree)
6. This biology course is exciting to me. (Strongly agree, Strongly disagree)
7. I like this biology course. (Strongly agree, Strongly disagree)

Utility Value

1. How useful is this biology course for what you want to do after you graduate? (Not at all useful, Very useful)
2. This biology course will be important when I get a job or go to graduate school. (Not at all useful, Very useful)
3. This biology course will be useful for me later in life. (Strongly agree, Strongly disagree)
4. Concepts in this biology course are useful because they will help me in the future. (Strongly agree, Strongly disagree)

Effort Cost (Strongly agree, Strongly disagree)

1. When I think about the hard work needed to get through my biology course, I am not sure that it will be worth it in the end.
2. I am not sure if I've got the energy do well in my biology course.
3. For me, taking this biology course just might not be worth the effort.

4. This biology course sounds like it really requires more effort than I'm willing to put into it.

Opportunity Cost (Strongly agree, Strongly disagree)

1. Studying for this biology course takes a lot of time away from other activities that I want to pursue.
2. I’m concerned about losing track of some valuable relationships because of the work required for this biology course.
3. I’m concerned that I have to give up a lot to do well in this biology course.
4. I’m concerned success in this biology course requires that I give up a lot of other activities I enjoy.
5. *I would rather leave more time for fun than for something as intense as this biology course.

Psychological Cost (Strongly agree, Strongly disagree)

1. I’m concerned about being embarrassed if my work in this biology course is inferior to that of my peers.
2. I’m concerned that my self-esteem will suffer if I am unsuccessful in this biology course.
3. I worry that others will think I am a failure if I do not do well in this biology course.
4. *I'm concerned that I'm not a good enough student to do well in this biology course.
5. * I’m anxious that I won't be able to handle the stress that goes along with this biology course.

*Removed items after factor analyses.

Supplemental Materials

Table S1

Model A Path Model Results

	Time 2 Variables							Final Grade on T2 Mot.
Time 1 Variables	Expectancy	Att. Value	Int. Value	Util. Value	Eff. Cost	Opp. Cost	Psy. Cost	
Expectancy	.57*	.20*	.18*	.07	-.03	.06	.09	.62*
Att. Value	.08	.32*	<.01	.01	-.24*	-.28*	-.20	.05
Int. Value	.05	.11	.56*	.06	-.05	-.12	.01	.04
Util. Value	-.04	.25*	.02	.66*	.02	**.19***	**.20***	-.08
Eff. Cost	**-.19***	-.09	-.07	-.11	.28*	-.11	.02	-.20*
Opp. Cost	.14	.07	.05	.11	-.01	.33*	-.02	.19*
Psy. Cost	.02	-.01	.06	-.01	.06	.18	.49*	-.07
Dummy Var 1	.09	-.02	-.03	.03	-.04	-.02	-.08	<.01
Dummy Var 2	.06	-.05	-.07	-.11	.09	.17	-.01	-.08
Dummy Var 3	.08	-.05	.03	.06	.02	<.01	-.01	.02

Note. All coefficients are standardized coefficients; The column Final Grade on T2 Mot. = the relations of the Time 2 motivation variables with Final Biology Grade; coefficients in bold became non-significant in Model B after fixing the other non-significant paths to 0 (these paths were retained in Model B); Att. Value = Attainment Value; Int. Value = Interest Value; Util. Value = Utility Value; Eff. Cost = Effort Cost; Opp. Cost = Opportunity Cost; Psy. Cost = Psychological Cost; Dummy Var 1 – 3 are the dummy variables for the experimental conditions; Final Grade = Final Biology Course Grade.

$^{*}p < .05$

Table S2

Model B2 Path Model Results with Effects of Non-Significant Relations from Model A Fixed to 0 and the Effects of the Intervention Freely Estimated

	Time 2 Variables							Final Grade on T2 Mot.
Time 1 Variables	Expectancy	Att. Value	Int. Value	Util. Value	Eff. Cost	Opp. Cost	Psy. Cost	
Expectancy	.59*	.20*	.15*	.00	.00	.00	.00	.65*
Att. Value	.00	.37*	.00	.00	-.21*	-.20*	.00	.00
Int. Value	.00	.00	.54*	.00	.00	.00	.00	.00
Util. Value	.00	.26*	.00	.70*	.00	.14	.13	.00
Eff. Cost	-.10*	.00	.00	.00	.30*	.00	.00	-.21*
Opp. Cost	.00	.00	.00	.00	.00	.31*	.00	.15*
Psy. Cost	.00	.00	.00	.00	.00	.00	.40*	.00
Dummy Var 1	.08	-.02	-.03	.04	-.06	-.03	-.07	<.01
Dummy Var 2	.06	-.06	-.08	-.11	.08	.15	<.01	-.06
Dummy Var 3	.07	-.04	.03	.07	<.01	.03	<.01	.02

Note. Model fit for Model B2: χ^2 (45) = 36.59, p = .810, RMSEA = .00, CFI = 1.00, SRMR = .03; all coefficients are standardized coefficients; the column Final Grade on T2 Mot. = the relations of the Time 2 motivation variables with Final Biology Grade; Att. Value = Attainment Value; Int. Value = Interest Value; Util. Value = Utility Value; Eff. Cost = Effort Cost; Opp. Cost = Opportunity Cost; Psy. Cost = Psychological Cost; Dummy Var 1 – 3 are the dummy variables for the experimental conditions; Final Grade = Final Biology Course Grade.

$^{*}p < .05$